## WEATHER BUREAU COOPERATION IN RECLAMATION WORK.[1]

By Mr. F. H. BRANDENBURG, District Forecaster.

Among the factors that enter into the consideration of irrigation projects it is manifest that the rainfall over the catchment basin is fundamental. The district embraced in what is known as the arid or semiarid region is so diversified in topography, so irregular as to the distribution of rainfall, and so varied as to the other climatic conditions that have a direct bearing on irrigation enterprises that no general discussion is applicable to all parts of the region. Hence, in these undertakings, it will be necessary to study the peculiarities of each locality with regard to evaporation, sunshine, winds, temperature, snowfall and rainfall.

In regard to rainfall, it may be broadly stated that east of the Continental Divide the warmer half of the year brings more than two-thirds of the annual amount, while on the western slope, as a rule, opposite conditions prevail. Precipitation is uncertain at best, and marked differences in the monthly as well as the yearly values are common. The notion is prevalent that an excess or deficiency of precipitation is followed by compensating conditions. A study of the data of the Denver station, which may be taken as illustrating the climatic conditions of the eastern slope, shows that conditions with respect to precipitation are even more variable than those pertaining to temperature and that *a notably dry or wet season is not likely to be followed by the opposite extreme, but rather by practically normal rainfall.*

While moderate rains lessen the need for irrigation and are highly beneficial to crop growth, they add but little to the volume discharged by the streams. During July and August downpours are not infrequent; nearly all the water finds its way into the streams in a few hours, causing damage to crops on the lowlands, to ditches and to railroads for miles along the valleys. Topography is a larger factor in connection with these heavy storms, or cloud-bursts, and certain localities are more likely than others to be visited. Doubtless the conserving of these waters will receive attention in time, notwithstanding the fact that water stored late in summer will be subject to a large loss by evaporation during the interval that must elapse before the next irrigation season.

Excepting certain large streams on the western slope, from which as yet but little water is diverted for irrigation purposes, our streams are normally low in midsummer, which is the critical time in crop growth, for, as a rule, the altitude is considerable and the planting season about four weeks later than in the same latitude in the great central valleys; the maturing of our crops is thus brought into the period when excessive heat and a scarcity of water are general. It is at such times that advantage is gladly taken of the supply afforded by any heavy local rains that may occur in the upper catchment basins. In Colorado a system of telegraphic reports of gage heights was initiated four years ago by the Weather Bureau, in cooperation with the Geological Survey, to give information in this regard. The volume discharged being published in the morning newspapers, the information was available to interested persons throughout the lower basins one or two days before the approach of the increased flow. Last year, unfortunately, the Geological Survey, owing to lack of funds, was unable to keep up the gaging stations, and this year a like condition in the Weather Bureau, as regards funds, has prevented a resumption of these reports. With an increased number of gaging stations it will be possible to gather quickly, at selected centers, advice regarding these temporary additions to the volume and to disseminate the information, by telegraph or otherwise, so that ditches of late construction that are not beneficiaries in times of scarcity may profit by that which would otherwise be lost to them.

Fortunately the mountain ranges, which are primarily the cause of the aridity prevailing in the western third of our country, furnish some compensating conditions by storing for the crop season the moisture collected in the form of snow during the winter. The period for which snow is thus stored is, of course, dependent on latitude, the altitude of the ranges, and whether they are covered with forests or are bare and fully exposed to the sun and high winds. The character of the spring, whether warm and early or cold and backward, is also an important factor in regulating the flow.

As indicating in a general way the area from which the greater part of the irrigation supplies must be drawn, it may be of interest to note that in Arizona the area of land 5000 feet and over in elevation is 47,120 square miles, or 42 per cent of the total area. Expressed in square miles the area in Washington above 7000 feet has been placed at 1000, or 2 per cent of the whole State; in Oregon 2800, or 3 per cent; in California 6246, or 4 per cent; in Idaho 4100, or 5 per cent; in Arizona 6700, or 6 per cent; in Nevada 13,000, or 12 per cent; in New Mexico 22,300, or 18 per cent; in Utah 20,441, or 24 per cent, and in Colorado 45,885, or 44 per cent.

Feeling assured that a knowledge of the snowfall in these high catchment basins would prove of great value to irrigation interests, the collection of statistics regarding the amount, the distribution, etc., was begun in Colorado during the winter of 1896–97 and published in bulletins, together with a forecast of the character and duration of the flow that might be expected. The snowfall bulletins, published regularly from December to March or April in the different mountain States, have a value beyond that of their current use, for to them reference must be had for information regarding the water supply of many catchment basins not represented by full meteorological reports.

Since variations in the amount and distribution of precipitation, so common in the Plains region, are not absent in the mountains, the volume furnished by melting snow is subject to marked fluctuations. Usually the maximum flow from this source is attained about the middle of June, after which the decline is rapid, unless the flow is augmented by rains. On the eastern slope, as in all highly developed sections, where the supply furnished by a normal snowfall is usually inadequate, except during a short period following maximum melting, a dry summer invariably emphasizes the importance of large reservoirs to tide over such seasons. It is also during these periods of drought that high winds are common and evaporation most pronounced, materially increasing the need for irrigation water, and at the same time appreciably diminishing the stock of snow. It is therefore apparent that evaporation is an important element to be considered in calculations pertaining to reservoirs. Complete data regarding the loss from this source are not available, but Prof. Thomas Russell has shown that during a year of normal temperature, wind, moisture, and sunshine evaporation from free water surfaces could reach 7 feet or more in the extreme eastern and southeastern parts of California. For Utah the possible loss was placed at 70 to 75 inches; for Colorado, between 65 and 70; for New Mexico, between 76 and 80 inches; for Arizona, from 55 to 60 inches in the upland districts and at about 100 inches in the Yuma desert. In Nevada the loss was found to be greatest, namely, 80 to 100 inches.

While for many parts of this vast area information in regard to the different climatic elements is necessarily incomplete, yet in scores of enterprises the data collected by the Weather

[1] The Eleventh National Irrigation Congress was held at Ogden September 15, 1903, and was attended by Mr. F. H. Brandenburg, District Forecaster; Robert M. Hardinge, Section Director, and Walter S. Palmer, Section Director, as representatives of the United States Weather Bureau. They were also appointed by the respective governors as delegates from Colorado, New Mexico, and Wyoming, respectively. This is the address presented by Mr. Brandenburg.—*C. A.*

Bureau have been found valuable aids to engineers and investors. Each State is a section of the Climate and Crop Service of the Bureau, in charge of an official whose duty it is to establish stations of observation. These stations are possible through the voluntary cooperation of public spirited citizens willing to act as observers. Observations include a record of the temperature, rainfall, snowfall, cloudiness, and prevailing winds; reports are rendered monthly, and after examination and computation at the section center, the values are published in quarto form about the 15th of the following month. These printed reports, with the addition of the annual summary, furnish a convenient source of information on climatic features, and may be had free of charge upon application. A considerable number of the stations have been in operation a great many years, while reports from others cover a comparatively short period. If the monthly publication does not give a report from the locality desired, application should be made to the section director for the information, as a copy of all records made at any time within the State in question is on file; thus, in Colorado, the number of discontinued stations is three times as large as that of the stations at present in operation, although these number nearly one hundred.

Records from mountain stations being especially important in the study of precipitation, efforts have been directed, for a number of years, toward increasing the number of observers on the upper watersheds, and while the number of such observers now cooperating is larger than ever before, there is room for a great many more in every section of the arid region.

The importance of these rainfall stations is not fully appreciated by the general public. In the beginning the work of reclamation will necessarily be confined to the larger and more promising undertakings, leaving relatively small ones for later consideration. When these latter are taken in hand full information must be available regarding the rainfall and its seasonal distribution, and whether it comes in small amounts or in an occasional downpour or cloud-burst. It lies within the power of this Congress to do much to encourage persons to undertake rainfall observations in the higher altitudes of the different States. As regards the furnishing of instrumental equipment, I feel sure there will be no difficulty, for Professor Moore, Chief of the Bureau, has the hearty cooperation of the Honorable Secretary of Agriculture in all matters that will further the interests of irrigation.

## HURRICANE IN THE GULF OF MEXICO.

By Capt. J. ELLIGERS, jr.

Mr. W. C. Devereaux, Assistant Observer, Havana, Cuba, forwards the following report by Capt. J. Elligers, jr., captain of the Norwegian steamship *Jason*, with reference to the hurricane of August 14 and 15. The exact location of the vessel is not known, other than as given in the extract from Captain Elligers's report:

We received a telegram at Tampico on August 11 from the United States Weather Bureau, stating that a hurricane was approaching the Mexican coast, but, as the following day did not show any signs of the approach of the storm and as our boat was new and well loaded, we sailed with a cargo of cattle at 2 p. m. of the 13th, direct for Havana. The weather was clear, with a light breeze from the east-northeast and a normal barometer. After midnight of the 13th the wind increased to a brisk breeze from the north-northeast. At 6 a. m. of the 14th, when we were about 150 miles east of Tampico, a gale suddenly blew up from the north, with heavy rain, the barometer began to fall rapidly, and the sea became very rough. The wind continued from the north with terrible force until 9 p. m. of that day, but seemed to be strongest between 12 noon and 4 p. m.; the rain fell in torrents, the air was sticky and much warmer than on the preceding day, and the sea was very rough. The barometer reached the lowest point at 8:30 p. m., one reading 29.24 and the other reading 29.13 (they were together before the storm). From 9 to 9:20 p. m. there was a dead calm; the rain had stopped, but the sea was terrible: the only thing I can compare it to is the boiling water in a mammoth kettle. At 9:20 p. m. the wind turned to south, through east, and the storm came with a sudden rush from that direction, and the wind blew with great force until 6 a. m. of the 15th. I can not estimate the velocity of the wind, but it was very high; I had to hold myself on the boat by clinging to a stanchion with both arms, and the wheelman had to stand in front of the wheel so that the wind would blow him against the wheel and not away from it.

During the 15th the storm gradually moderated, and on the 16th the hatches, which had been closed for three days, were opened and 270 dead cattle were removed from a cargo of 613. It was by far the worst storm I ever encountered, and I have been a sailor all my life.

*Abstract of log of steamship Jason.*

| Date. | Barometer. | | Remarks. |
|---|---|---|---|
| 1903. | *Mm.* | *Inches.* | |
| Aug. 13, 2 p. m. | 762.0 | 30.00 | Fine weather; light breeze from ene.; left Tampico. |
| 4 p. m. | 762.2 | 30.01 | Fine weather: light breeze from ene. |
| 8 p. m. | 762.0 | 30.00 | Do. |
| 14, 12 midnight. | 762.0 | 30.00 | Fine weather; fresh breeze from ene. |
| 4 a. m. | 760.0 | 29.92 | Cloudy; strong breeze nne. |
| 5 a. m. | 760.0 | 29.92 | Do. |
| 6 a. m. | 759.8 | 29.91 | Heavy rain; wind north, blowing up suddenly to storm. |
| 7 a. m. | 759.5 | 29.90 | Heavy rain; wind north; storm; heavy sea. |
| 8 a. m. | 759.0 | 29.88 | Do. |
| 9 a. m. | 758.0 | 29.84 | Heavy rain; wind north, increasing to hurricane; heavy sea; warm and oppressive. |
| 10 a. m. | 757.0 | 29.80 | Do. |
| 11 a. m. | 756.0 | 29.76 | Do. |
| 12 m. | 755.0 | 29.72 | Heavy rain; wind north, hurricane; heavy sea; warm and oppressive. |
| 1 p. m. | 752.5 | 29.63 | Do. |
| 2 p. m. | 751.0 | 29.57 | Do. |
| 3 p. m. | 750.0 | 29.53 | Do. |
| 4 p. m. | 749.0 | 29.49 | Do. |
| 5 p. m. | 747.0 | 29.41 | Do. |
| 6 p. m. | 745.0 | 29.33 | Do. |
| 7 p. m. | 744.0 | 29.31 | Do. |
| 8 p. m. | 743.5 | 29.27 | Do. |
| 8:30 p. m. | 742.8 | 29.24 | Do. |
| 9 p. m. | 743.6 | 29.25 | Dead calm. |
| 10 p. m. | 744.5 | 29.31 | Hurricane. |
| 15, 12 midnight. | 745.0 | 29.33 | Do. |
| 4 a. m. | 750.0 | 29.53 | Do. |
| 8 a. m. | 759.0 | 29.88 | Storm. |
| 12 m. | 761.5 | 29.98 | Strong gale. |

At 9 p. m. of the 14th a great calm, and then the wind turned from north through east to south. At 9:20 the cyclone came with a sudden rush from south, glass rising. Wind blew with terrible force right up to 6 a. m. of the 15th; after that time it went slowly down to storm, strong gale, and fresh breeze at 12 midnight of August 15–16. The sea was very rough at the time and there were heavy rain squalls all the time. During the hurricane the temperature of the air was about 31° Celsius, and before the hurricane it was not more than 27°–29° in the middle of the day. Sunday morning, the 16th, the wind was fresh breeze from east and the sea very moderate.

## METHODS OF METEOROLOGICAL INVESTIGATION.

By W. N. SHAW, Superintendent of the Meteorological Office, London.

An address before Section A, of the British Association for the Advancement of Science, at Southport, England, September 10, 1903.

[Reprinted from the author's corrected separate print.]

In opening the proceedings of the subsection devoted to cosmical physics, which we may take to be the application of the methods and results of mathematics and physics to problems suggested by observations of the earth, the air, or the sky, I desire permission to call your attention to some points of general interest in connection with that department which deals with the air. My justification for doing so is that this is the first occasion upon which a position in any way similar to that which I am now called upon to fill has been occupied by one whose primary obligations are meteorological. That honour I may with confidence attribute to the desire of the Council of the Association to recognise the subject so admirably represented by the distinguished men of science who have come across the seas to deliberate upon those meteorological questions which are the common concern of all nations, and whom we are specially glad to welcome as members of this subsection. Their presence and their scientific work are proof, if proof is required, that meteorologists can not regard meteorological problems as dissociable from section A; that the prosecution of meteorological research is by the study of the kinematics, the mechanics, the physics, or the mathematics